GLASSES IN TUCSON (IRUNGR): A SIMS STUDY

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Introduction:

Tucson is a unique ataxite iron meteorite with about 8% volatile silicates [1]. The Si (0.8 wt%) and the very low Ge content of the metal [2] make Tucson distinct among the iron meteorites, with silicate inclusions [3]. Silicate inclusions from Tucson, first reported by [4], have a remarkably reduced state [5]. Detailed chemical and mineralogical studies of these inclusions [1, 6] include a description of glasses that occur between crystalline phases. However, there has been no mention of the presence of primary glass inclusions in olivines. Here we report the first trace element study of glasses from glass inclusions in olivines and mesostasis glasses occurring between phases in the Tucson iron meteorite.

Both types of glasses (glass inclusions in olivine (Glass I.1) and mesostasis glass between olivines (Glass, Table) have a Si-Al-Ca-Rich composition, with the glass inclusion having a higher content of SiO2 (e.g., 57 wt%) and a lower content of A2O3 (e.g., 21.4 wt%) compared to the glass between olivines (SiO2: 48.9 wt%, A2O3: 28.1 wt%). Both types of glasses have similar CaO contents (~20 wt%), very low contents of FeO and are free of Na and K.

Results:

Tucson glasses have a remarkably reduced state [5] - they can represent samples of the first liquid (e.g., the glass precursor) to condense from the solar nebula. According this view, the Si-Al-Ca-Rich composition of glasses in Tucson as well as their elemental ratios (e.g., Ca/Si) is expected from the PLC model for a carbonaceous chondrite silicate assemblage. Similarly, the trace element contents of the glass inclusion and the glass mesostasis between olivines also match those observed in glasses hosted by olivines and mesostasis in carbonaceous chondrites [11-12].

Trace element contents of both types of glasses are similar, with refractory elements having abundances around 10 x CI (Fig. 2). Exceptions are Nb (0.1 – 2.4 x CI), Ti (0.08 x CI) and Sc (0.8 – 1.3 x CI), which are depleted with respect to the other refractory trace elements. The REEs show an unfractionated pattern with abundances varying around 5 to 10 x CI. With respect to the moderately volatile and volatile elements, glasses show variable contents of Be, with inclusion glasses (Glass I.1) having higher contents (100 x CI) than Glass 4 (4 x CI). With respect to Sr, Ba and B, Glass 4 has higher contents of these elements (Sr: ~25 x CI, Ba: ~11 x CI) than Glass I.1 (Br: ~11 x CI, B: 0.3 x CI). Both glasses have relatively low contents of the moderately volatile elements Cr (0.2 – 0.7 x CI) as well as of V (0.5–1.2 x CI).

Discussion:

The Tucson section L3951 is a very antique glass-covered thin section. During the tasks of uncovering and re-polishing, part of the material was unfortunately lost. However, the very particular feature of the silicate inclusions is still visible, namely a parallel or sub-parallel curved aggregate arrangement, which in previous studies [6, 1] has been interpreted to indicate flow. The microstructure of the metal and its chemical homogeneity has led to the suggestion [7] that in Tucson the metal underwent rapid cooling (about 1ºC/1000 years). Because of the apparent flow structure shown by the silicates it has been suggested that the silicate mass was invaded by shock melted metal. Similarly, [1] proposed a turbulent impact mix of metal and a forsterite-enstatite silicate assemblage at high temperatures that resulted in volatilization of Gs and other volatile elements. Subsequent rapid cooling appears to be supported by the aluminous pyroxenes and the presence of glass in the silicate inclusions. Accordingly, the forsterite-enstatite silicate assemblage has been related to enstatite meteorites. However, in addition, a comparison of glass compositions in the Tucson silicate inclusion and those in enstatite chondrites and achondrites clearly shows that they are compositionally related.

Conclusion:

Glasses in the Tucson iron meteorite provide a set of data that strengthens the PLC model and provides an additional step toward meteorite unification [16]. Beyond the element abundance data, the particular textures shown by silicate inclusions, where olivines have crystal faces only in contact with the glass, might serve as a natural example for the proposed growing mechanism of crystals from a vapor with the help of a thin layer of surrounding liquid (Fig.1). All phases in Tucson, silicates and metal, appear to have a simple, one-step nebular origin after which they became isolated and protected from subsequent processing.

Table EMP analyses of glass and olivine in Tucson

<table>
<thead>
<tr>
<th>Glass</th>
<th>OL host</th>
<th>Glass 4</th>
<th>OL</th>
<th>Ol</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO2</td>
<td>57.0</td>
<td>42.8</td>
<td>48.9</td>
<td>42.0</td>
</tr>
<tr>
<td>A2O3</td>
<td>21.4</td>
<td>28.1</td>
<td>21.4</td>
<td>28.1</td>
</tr>
<tr>
<td>FeO</td>
<td>0.19</td>
<td>0.19</td>
<td>0.81</td>
<td>0.23</td>
</tr>
<tr>
<td>MgO</td>
<td>1.58</td>
<td>5.72</td>
<td>3.17</td>
<td>5.67</td>
</tr>
<tr>
<td>CaO</td>
<td>19.6</td>
<td>16.0</td>
<td>19.6</td>
<td>11.1</td>
</tr>
<tr>
<td>99.8</td>
<td>100.4</td>
<td>100.6</td>
<td>98.9</td>
<td>99.2</td>
</tr>
</tbody>
</table>

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Figure 2. CI-normalized trace element abundances in glasses of the Tucson meteorite. Glasses from Renazzo (in red) are plotted for comparison [10].

References: